US009438486B2

(12) **United States Patent**
Shaw et al.

(10) **Patent No.: US 9,438,486 B2**
(45) **Date of Patent: Sep. 6, 2016**

(54) **INTELLIGENT NETWORK DIAGNOSIS AND EVALUATION VIA OPERATIONS, ADMINISTRATION, AND MAINTENANCE (OAM) TRANSPORT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 528 days.

(21) Appl. No.: **13/517,838**

(22) Filed: **Jun. 14, 2012**

(65) **Prior Publication Data**

US 2013/0336128 A1 Dec. 19, 2013

(51) **Int. Cl.**

G01R 31/08	(2006.01)
H04L 12/24	(2006.01)
H04L 12/26	(2006.01)
H04L 12/823	(2013.01)
H04W 24/02	(2009.01)
H04L 12/801	(2013.01)
H04W 24/00	(2009.01)

(52) **U.S. Cl.**
CPC ***H04L 41/5038*** (2013.01); ***H04L 43/103*** (2013.01); ***H04L 43/12*** (2013.01); ***H04L 47/323*** (2013.01); ***H04W 24/02*** (2013.01); *H04L 47/12* (2013.01); *H04W 24/00* (2013.01)

(58) **Field of Classification Search**
USPC 370/230, 230.1, 235, 236, 236.2, 241.1, 370/242, 243, 244, 245, 252
See application file for complete search history.

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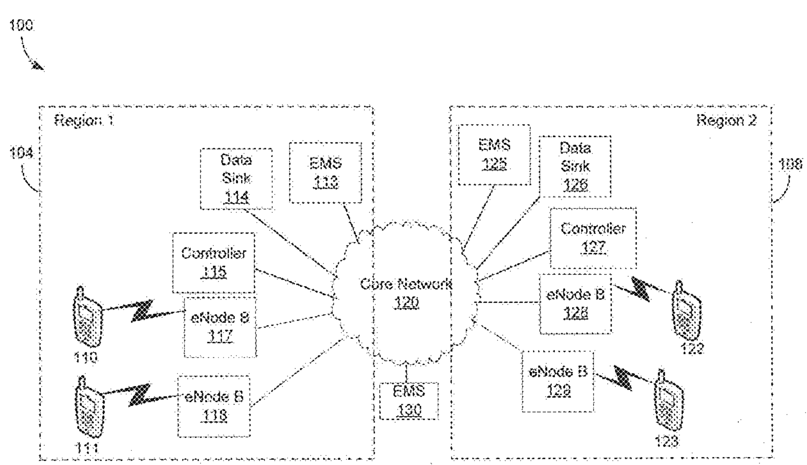
(57) **ABSTRACT**

An operation, administration, and maintenance data sink may receive an event data packet. The event data packet may be processed and transmitted based on instructions from a controller, wherein the controller may regulate the transmission of the processed event data packet based on network conditions.

14 Claims, 9 Drawing Sheets



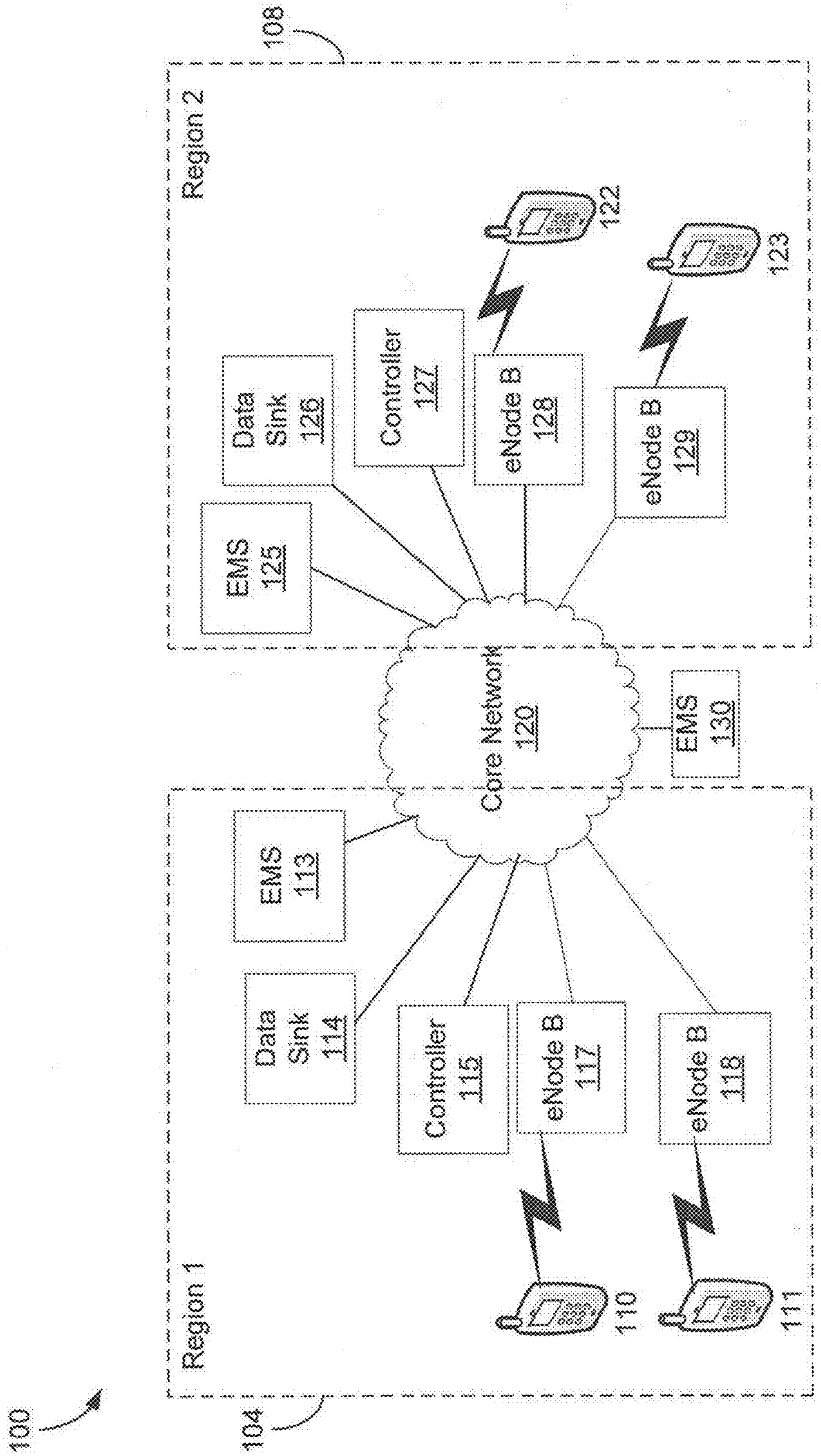

100
104
108
Region 1
Region 2
EMS 113
Data Sink 114
Controller 115
eNode B 117
eNode B 118
110
111
Core Network 120
EMS 130
EMS 125
Data Sink 126
Controller 127
eNode B 128
eNode B 129
122
123

Figure 1

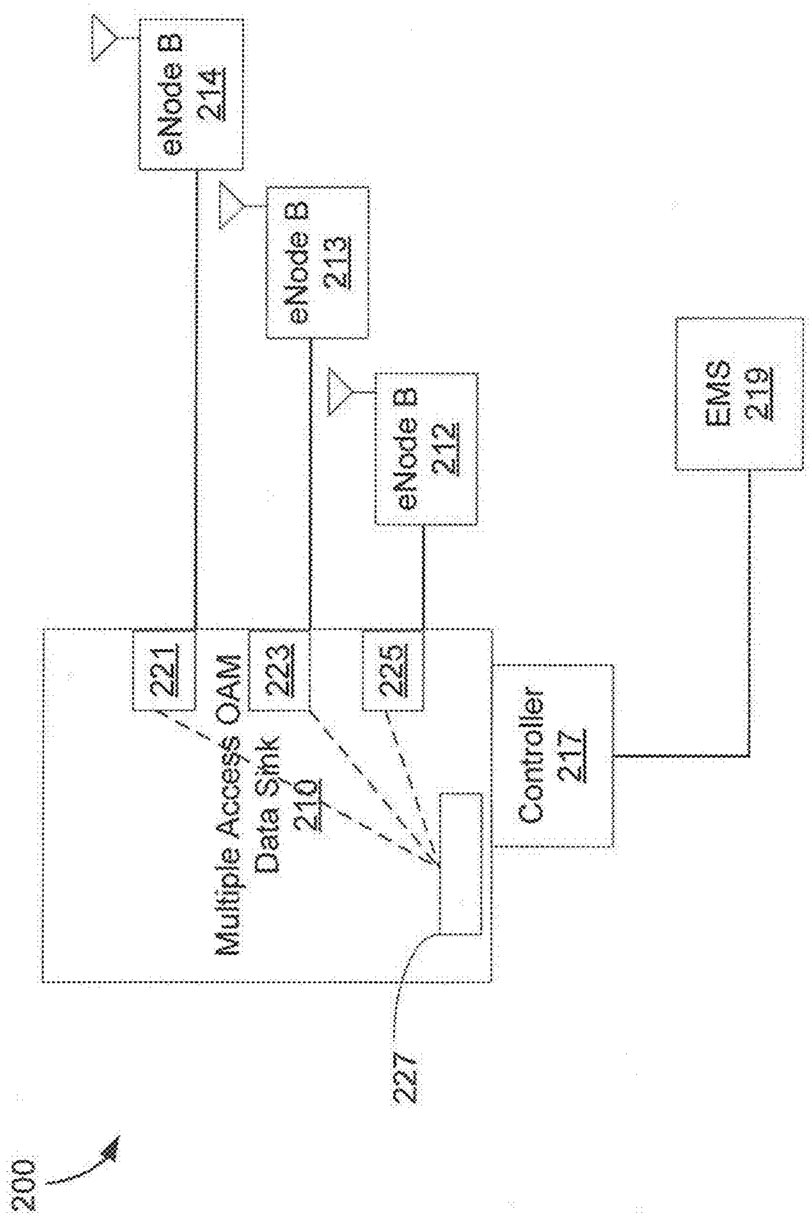

eNode B
214
eNode B
213
eNode B
212
EMS
219
221
223
225
Multiple Access OAM
Data Sink
210
Controller
217
227
200

Figure 2

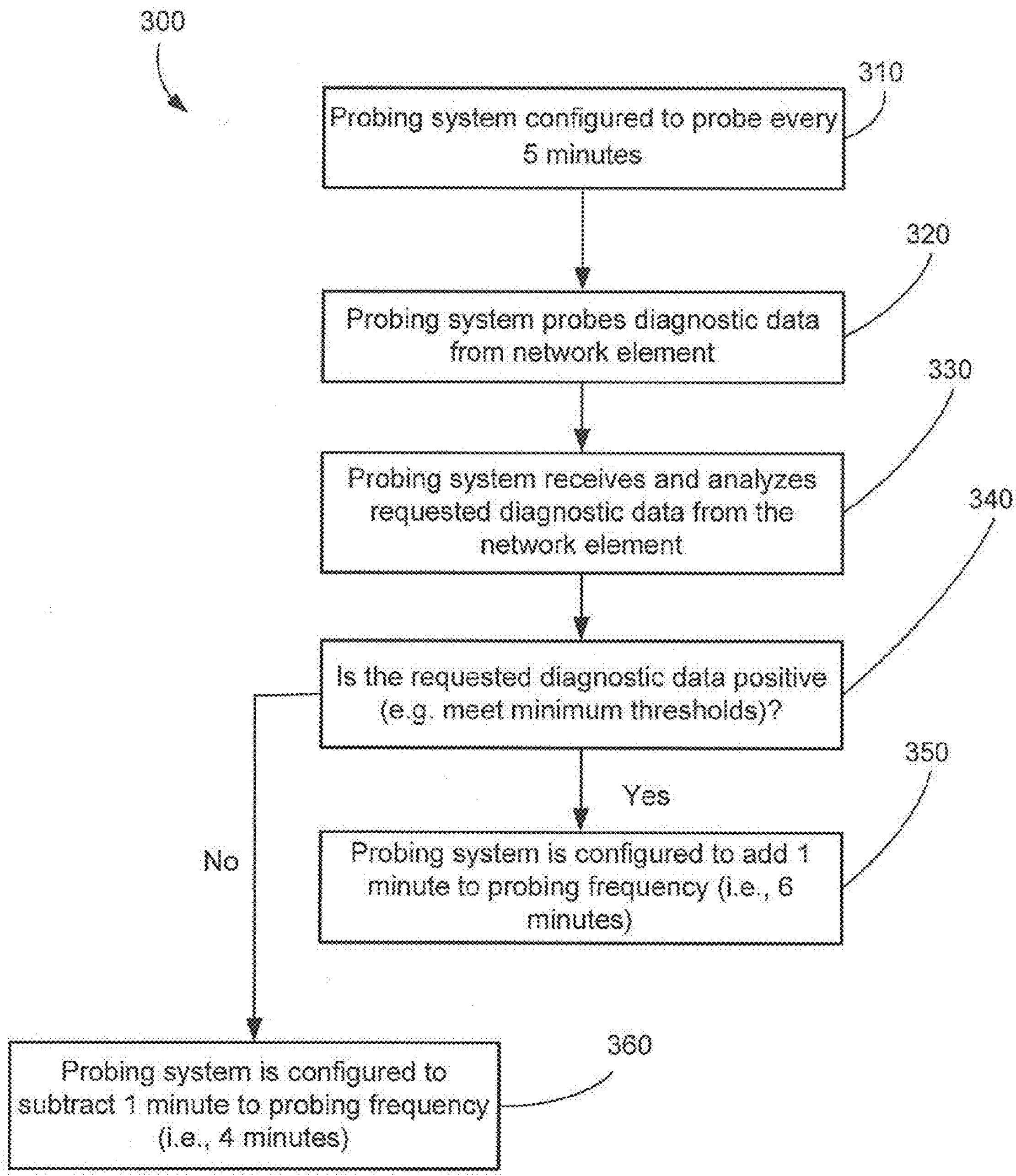

300
310
Probing system configured to probe every 5 minutes
320
Probing system probes diagnostic data from network element
330
Probing system receives and analyzes requested diagnostic data from the network element
340
Is the requested diagnostic data positive (e.g. meet minimum thresholds)?
Yes
No
350
Probing system is configured to add 1 minute to probing frequency (i.e., 6 minutes)
360
Probing system is configured to subtract 1 minute to probing frequency (i.e., 4 minutes)

Figure 3

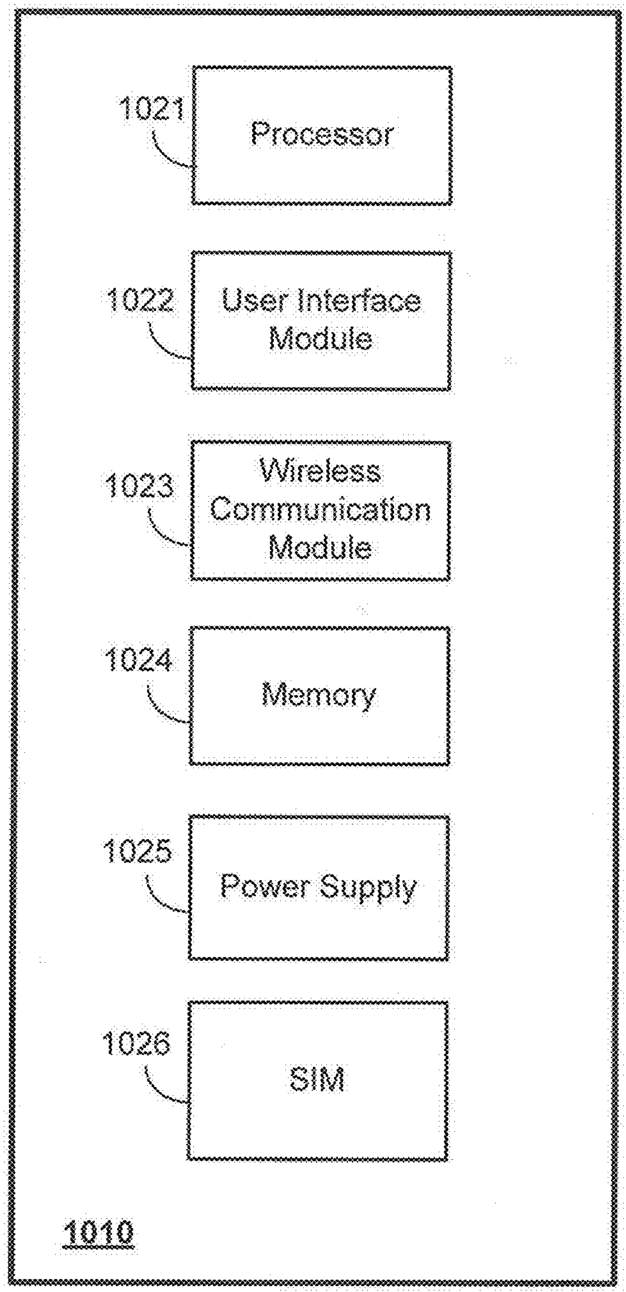

1021
Processor
1022
User Interface Module
1023
Wireless Communication Module
1024
Memory
1025
Power Supply
1026
SIM
1010

Figure 4

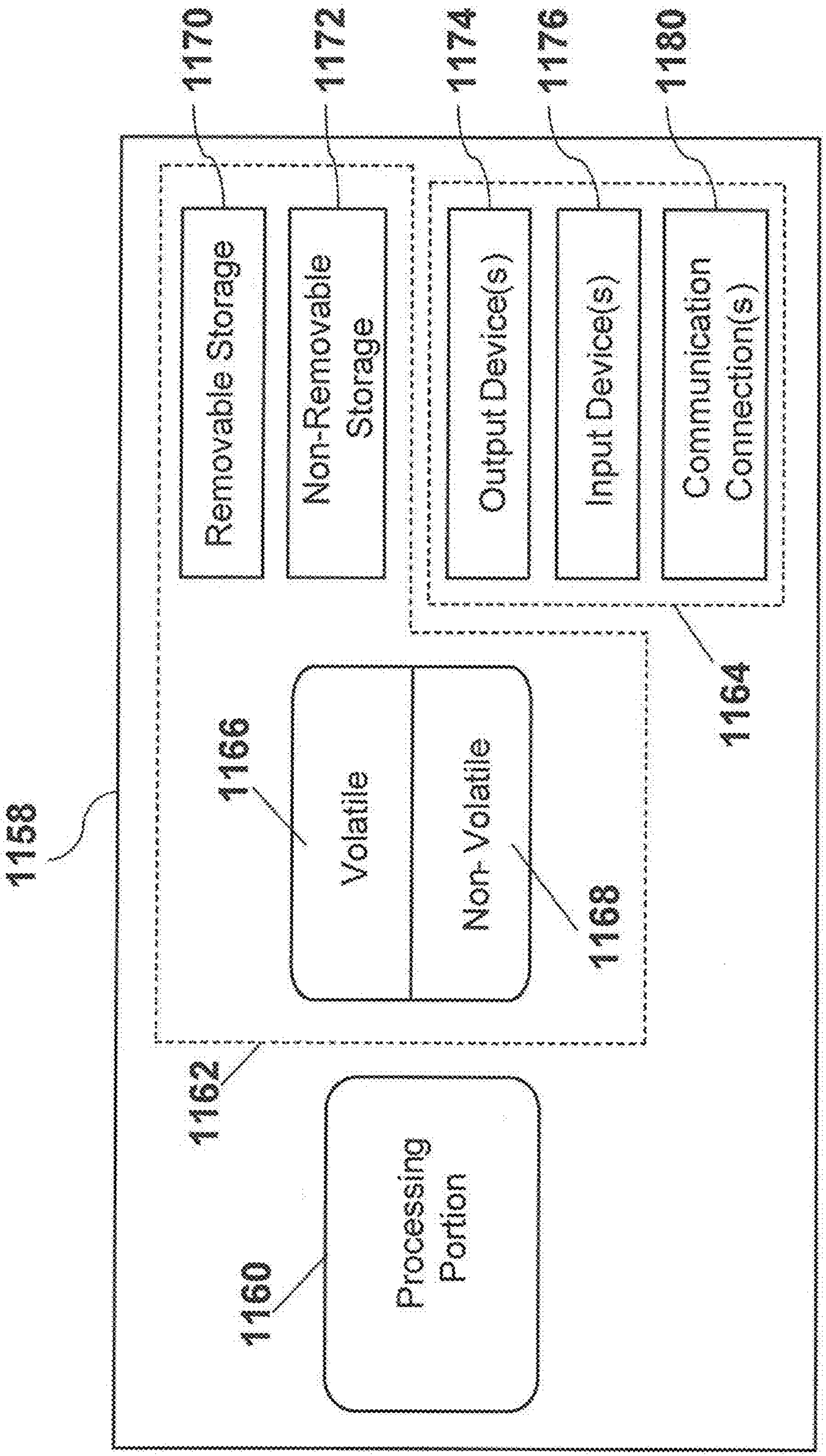
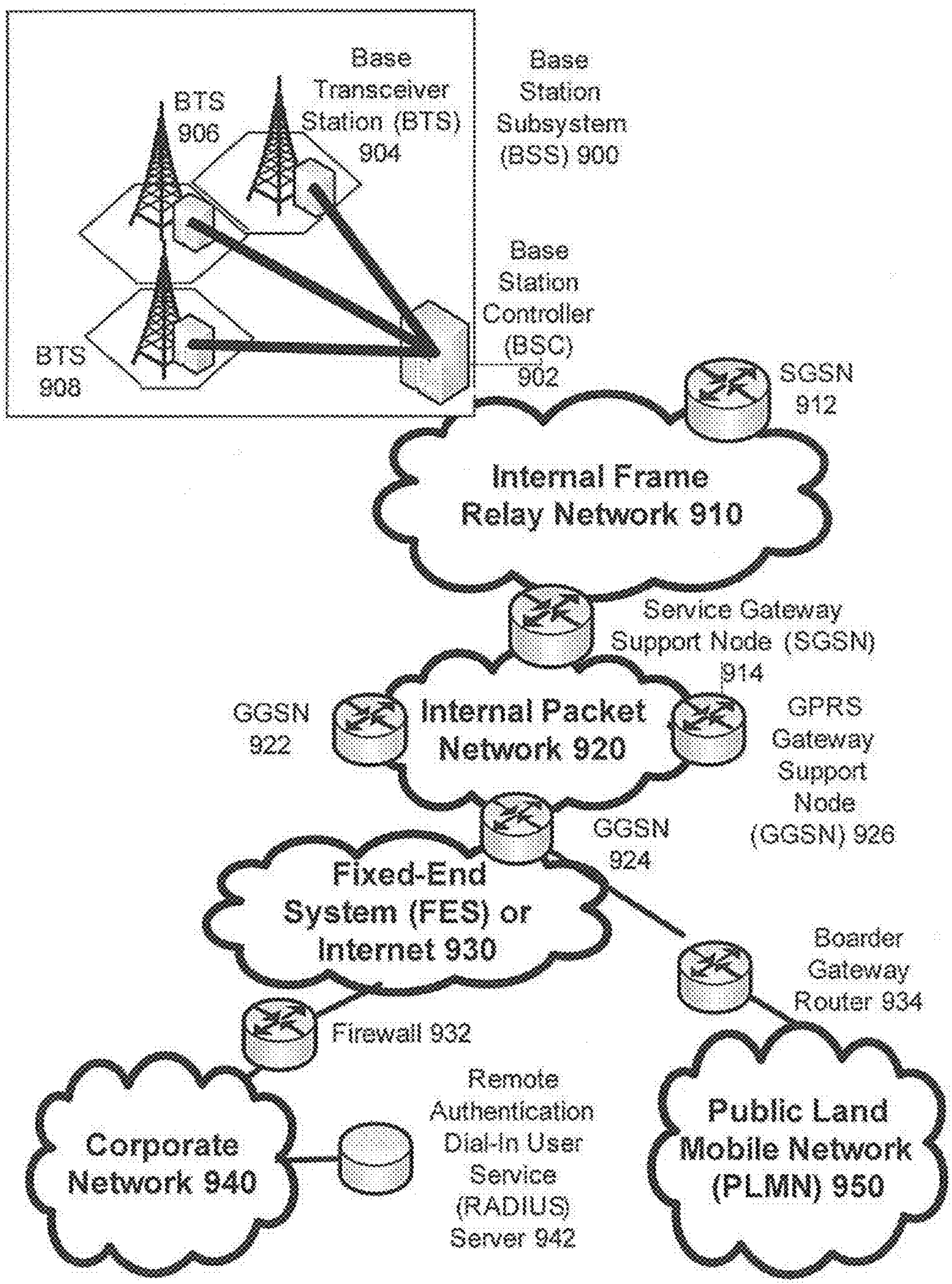

1158
1160
Processing Portion
1162
1166
Volatile
Non- Volatile
1168
1170
Removable Storage
1172
Non-Removable Storage
1164
1174
Output Device(s)
1176
Input Device(s)
1180
Communication Connection(s)

Figure 5



Base Transceiver Station (BTS) 904
BTS 906
BTS 908
Base Station Subsystem (BSS) 900
Base Station Controller (BSC) 902
SGSN 912
Internal Frame Relay Network 910
Service Gateway Support Node (SGSN) 914
GGSN 922
Internal Packet Network 920
GPRS Gateway Support Node (GGSN) 926
GGSN 924
Fixed-End System (FES) or Internet 930
Boarder Gateway Router 934
Firewall 932
Remote Authentication Dial-In User Service (RADIUS) Server 942
Corporate Network 940
Public Land Mobile Network (PLMN) 950

Figure 6

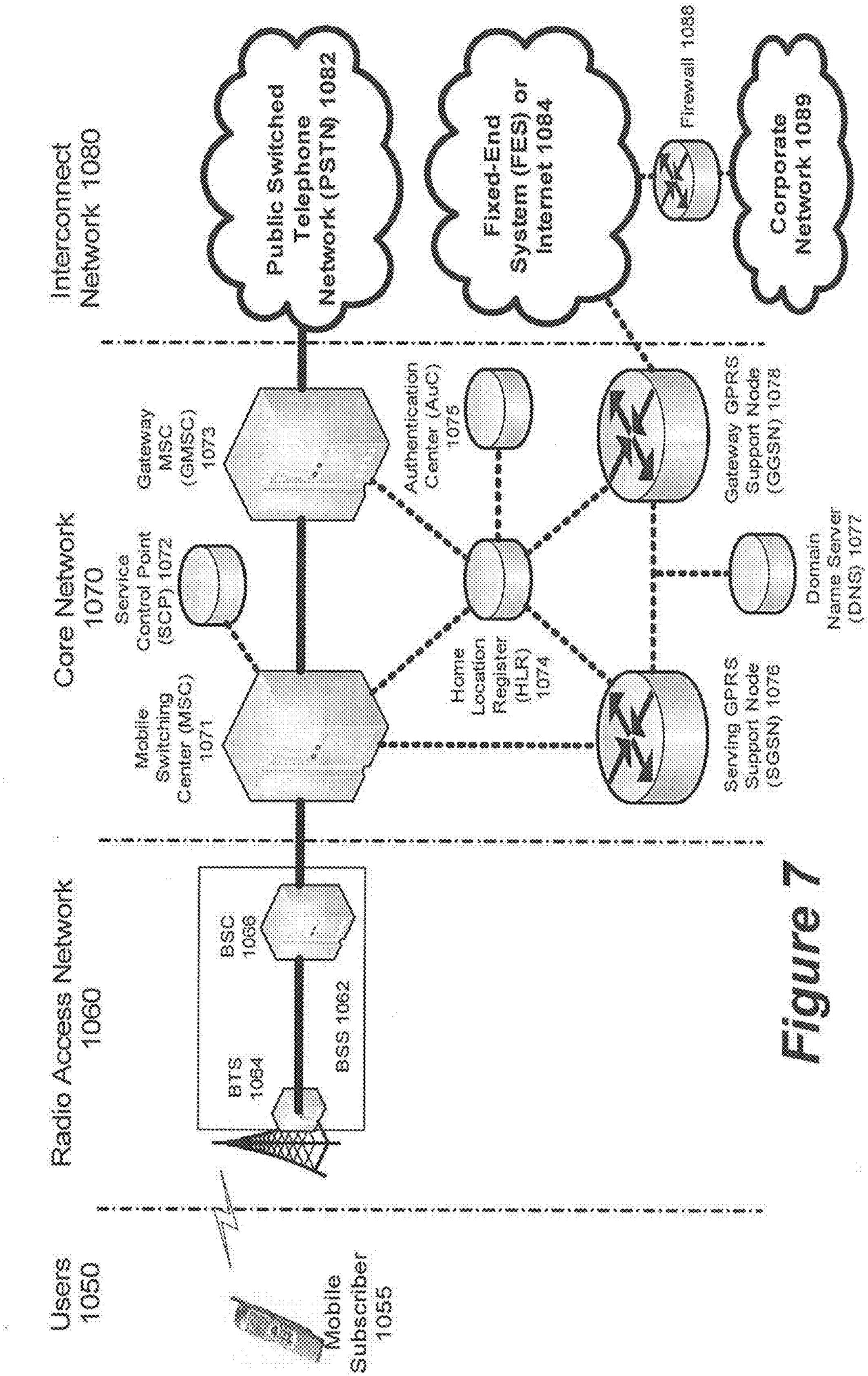

Users
1050
Mobile
Subscriber
1055
Radio Access Network
1060
BTS
1064
BSC
1066
BSS 1062
Core Network
1070
Mobile
Switching
Center (MSC)
1071
Service
Control Point
(SCP) 1072
Gateway
MSC
(GMSC)
1073
Home
Location
Register
(HLR)
1074
Authentication
Center (AuC)
1075
Serving GPRS
Support Node
(SGSN) 1076
Domain
Name Server
(DNS) 1077
Gateway GPRS
Support Node
(GGSN) 1078
Interconnect
Network 1080
Public Switched
Telephone
Network (PSTN) 1082
Fixed-End
System (FES) or
Internet 1084
Firewall 1088
Corporate
Network 1089

Figure 7

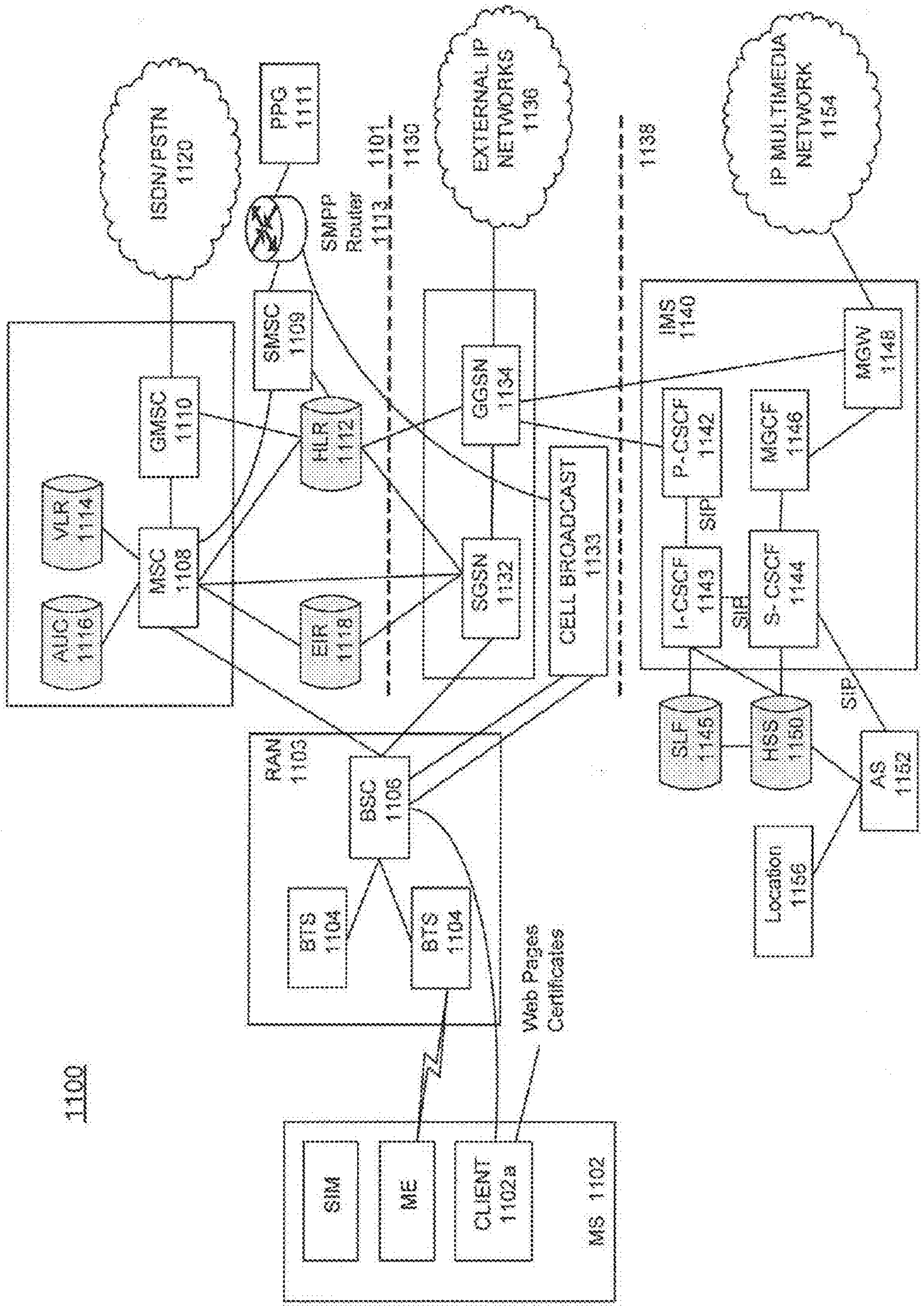

1100
MS 1102
SIM
ME
CLIENT 1102a
Web Pages Certificates
RAN 1103
BTS 1104
BTS 1104
BSC 1106
AUC 1116
VLR 1114
MSC 1108
GMSC 1110
ISDN/PSTN 1120
SMSC 1109
HLR 1112
EIR 1118
SMPP Router
PPG 1111
1101
1113
1130
SGSN 1132
GGSN 1134
EXTERNAL IP NETWORKS 1136
CELL BROADCAST 1133
1138
IMS 1140
I-CSCF 1143
P-CSCF 1142
S-CSCF 1144
MGCF 1146
MGW 1148
SIP
SIP
SIP
IP MULTIMEDIA NETWORK 1154
SLF 1145
HSS 1150
AS 1152
Location 1156

Figure 8

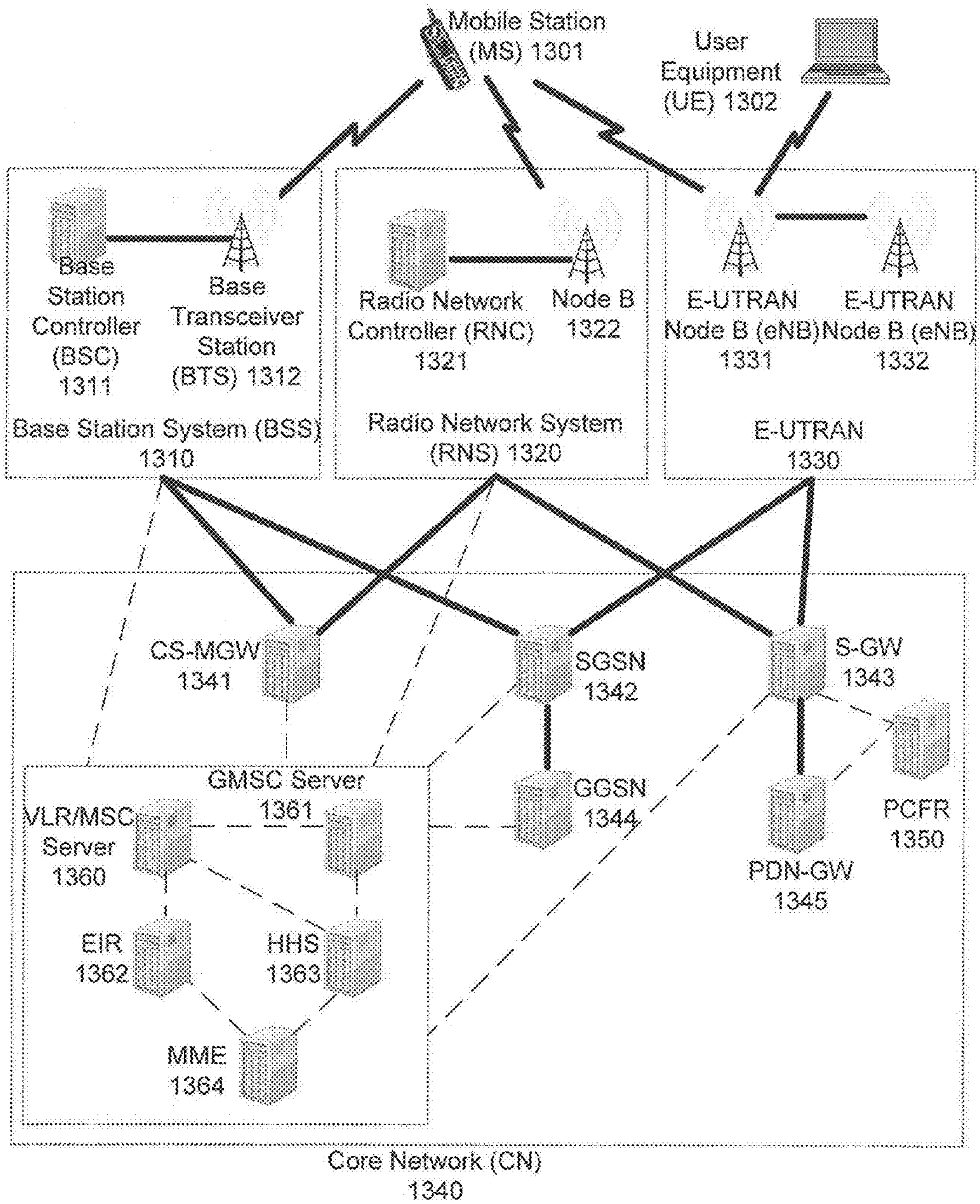


Figure 9

NOTE Solid Lines represent user traffic signals while dashed lines represent support signaling

INTELLIGENT NETWORK DIAGNOSIS AND EVALUATION VIA OPERATIONS, ADMINISTRATION, AND MAINTENANCE (OAM) TRANSPORT

BACKGROUND

Currently an OAM sever may be contacted by network elements (NEs) directly at varying times in order to report device and network management data. There continues to be more and more networked devices that demand increased bandwidth, resulting in data collection becoming more challenging and unmanageable. While end-customer demands continue to increase, so do the requirements for service providers to quickly diagnose and repair network issues.

SUMMARY

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the Detailed Description. This summary is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Furthermore, the claimed subject matter is not limited to limitations that solve any or all disadvantages noted in any part of this disclosure.

In an embodiment, a method may comprise receiving, by an operations, administration, and maintenance (OAM) data sink, an event data packet, and processing the event data packet into a first OAM data packet, wherein the transmission of the first OAM data packet may regulated by a controller based on network conditions.

In another embodiment, a network device in communication with a long-term evolution (LTE) network may comprise a processor configured to process an event data packet into a first operations, administration, and maintenance (OAM) data packet, and regulate the transmission of the first OAM data packet based on network conditions. In addition, a transceiver may be in communication with the processor and configured to receive the event data packet and transmit the first OAM data packet based on instructions from a controller.

In another embodiment, a probing device in communication with a long-term evolution network may comprise a transceiver and a processor. The transceiver may be configured to transmit a probe to a first network device in communication with the long-term evolution network. The processor in communication with the transceiver may be configured to determine a condition of the first network device based on the response to said probe and adjust subsequent probing based on the determined condition.

BRIEF DESCRIPTION OF THE DRAWINGS

The following detailed description of example embodiments is better understood when read in conjunction with the appended drawings. For the purposes of illustration, there is shown in the drawings exemplary embodiments; however, the subject matter is not limited to the specific elements and instrumentalities disclosed. In the drawings:

FIG. **1** illustrates a non-limiting exemplary network configuration for long term evolution (LTE) according to one or more disclosed embodiments of intelligent network diagnosis and evaluation.

FIG. **2** illustrates a non-limiting exemplary network configuration for LTE according to one or more disclosed embodiments of intelligent network diagnosis and evaluation.

FIG. **3** illustrates a non-limiting exemplary method of implementing one or more disclosed embodiments of intelligent network diagnosis and evaluation.

FIG. **4** is a block diagram of a non-limiting exemplary mobile device in which aspects of one or more disclosed embodiments of intelligent network diagnosis and evaluation may be implemented.

FIG. **5** is a block diagram of a non-limiting exemplary processor in which aspects of one or more disclosed embodiments of intelligent network diagnosis and evaluation may be implemented.

FIG. **6** is a block diagram of a non-limiting exemplary packet-based mobile cellular network environment, such as a GPRS network, in which one or more disclosed embodiments of intelligent network diagnosis and evaluation may be implemented.

FIG. **7** illustrates a non-limiting exemplary architecture of a typical GPRS network, segmented into four groups, in which one or more disclosed embodiments of intelligent network diagnosis and evaluation may be implemented.

FIG. **8** illustrates a non-limiting alternate block diagram of an exemplary GSM/GPRS/IP multimedia network architecture in which one or more disclosed embodiments of intelligent network diagnosis and evaluation may be implemented.

FIG. **9** illustrates a PLMN block diagram view of an exemplary architecture in which one or more disclosed embodiments of intelligent network diagnosis and evaluation may be implemented.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

FIG. **1** is an exemplary illustration of a communications system **100** in which one or more of the disclosed embodiments may be implemented. In FIG. **1**, a wireless transmit/receive unit (WTRU) **110** and WTRU **111** may be connected, respectively, to eNode B (eNB) **117** and eNode B **118**. The eNode B **117** and eNode B **118** may be connected to core network **120**. Core network **120** may be connected to a controller **115**, a multiple access operations, administration, and maintenance (OAM) data sink **114**, and a regional element management system (EMS) **113** (e.g., OAM server). WTRU **110** and **111**, eNode B **117** and **118**, EMS **113**, data sink **114**, and controller **115** may reside in Region 1 **104** (square **104**). All of the equipment within Region 1 may be defined by a physical topology or logical topology, for example.

Also, in FIG. **1**, there may be a Region 2 delineated by square **108**. Region 2 may comprise WTRU **122** and **123**, eNode B **128** and **129**, EMS **125**, multiple access OAM data sink **126**, and controller **127**. WTRU **122** and WTRU **123** may be respectively connected to eNode B **128** and eNode B **129**. The eNode B **128** and eNode B **129** may be connected to core network **120**. Core network **120** may also be connected to controller **127** and regional EMS **125**. All of the equipment within Region 2 may be defined by a physical topology, logical topology, or the like. Although not shown, communication system **100** may have several defined regions with similar equipment as shown in communication system **100**. There may be a centralized EMS **130** that may talk to all other regional EMS nodes or the regional nodes may talk to each other directly for handoff and other data collection and data analysis purposes. Regional EMS nodes as well as regional controllers and other equipment, as shown in FIG. **1** and discussed herein, may allow for more efficient use of resources and may allow for more efficient distributed data collection. For example, a regional EMS node as compared to having a national node may allow for quicker response to a request for near real time management of a region, if needed. Near real-time management of a region may be requested because of suspected or actual issues with networking equipment in the region.

FIG. **2** is an exemplary illustration of a communication system **200** in which one or more of the disclosed embodiments of intelligent network diagnosis and evaluation may be implemented. Communication system **200** may be one of a plurality of communication systems that may be located in a distinct region. A region may be defined by a metro area, county, state, multi-state area, or the like. The eNode Bs **212**, **213**, and **214** are network elements that may be communicatively connected to a multiple access OAM data sink **210**. Multiple access OAM data sink **210** may be communicatively connected to controller **217** and controller **217** may be communicatively connected to a regional EMS **219**. A data sink, as disclosed herein, may generally be defined as an object (i.e., data) that may be bound to external data (such as a database) that is made available by a data source (database). Here, regional EMS **219** may push event collection configuration profiles down to each of its managed eNode Bs **212**, **213**, and **214**. Event collection configuration profiles may be considered instructions regarding the collection of a type of event or collection of a type of measurement category and how often to collect the event or other measurement. Network elements may collect an event according to the event collection configuration and record the time of the event. Collected events may each have different content (binary data) and size. A collected event may be from a periodic measurement sampling or triggered sampling.

In an embodiment, there may be OAM data used for dynamic network resource reallocation. For example, if the backhaul utilization of eNB **213** approached a threshold level indicating maximum capacity, controller **217** may detect the maximum capacity indicator based on event data (OAM data) transmitted to the OAM data sink **210** by eNB **212**, and the controller may make a recommendation to EMS **219**. In turn, EMS **219** may direct eNB **213** to reduce its coverage area and may have eNB **212** and eNB **214** increase their coverage area. The appropriate decrease in coverage area for eNB **213** may allow less WTRUs to access eNB **213** and, in turn, may decrease the backhaul utilization of eNB **213** while increasing the utilization for eNB **212** or eNB **214**.

Data sink **210** may be an intermediary and gather data from all eNBs in the region, wherein the eNB's may send data at varying times and amounts. Data sink **210** may transmit event data gathered from the regional eNBs periodically. Data sink **210** may transmit data every 15 minutes, for example, since 15 minutes is a logical, sufficiently frequent time frame. In an embodiment, the event data that will be transmitted by data sink **210** may be compressed before being sent to EMS **219**. Controller **217** may analyze the gathered event data from each of the eNBs and use a minimal number of bits to represent event data. For example, if event/management data has minimal or no change, controller **217** may replace the several bit representation with a bit indicating "no change" that the EMS **219** can interpret as such.

In an embodiment, data sink **210** may gather event data from eNB **214**, **213**, and **212** and periodically transmit the data every 15 minutes. During the transmission the controller **217** may monitor the network conditions and provide instructions to data sink **210** on whether to slow down (e.g., 64 kb/s) or speed up (e.g., 2 Mb/s) the transmission of event data to EMS **219**.

In communication system **200**, the OAM data from the eNB may initially be buffered separately for each respective eNB. For example, eNB **214** may have event data (OAM data) saved at buffer **221**, eNB **213** may have event data saved at buffer **223**, and eNB **212** may have event data saved at buffer **225**. After reaching a threshold which may comprise considerations of the amount of data received or the amount of time that has passed, data sink **210** may combine the event data from buffers **221**, **223**, and **225** into packet **227**. Controller **217** may analyze the time between OAM messages to the EMS **219** and the amount of data within data sink **210** in order to decide whether packet **227** may be sent to EMS **219**. In an embodiment, if event data buffer at block **214** corresponding to network element **214** reaches a high level, (e.g., 90%, which may be configured by controller **217**), all data in the event data buffer may be purged and transmitted immediately to an EMS. As stated herein, functions of data sink **210**, controller **217**, and EMS **219** may be located on one device, distributed as shown, or distributed in another manner.

Network elements (NEs), such as eNode Bs, may collect events according to the configuration profile of a regional EMS. Generally events may concern signal strength, and resource utilization level, among other things. There may be periodic event measurement sampling or triggered event measurement sampling. With regard to triggered events, these events may occur in a random manner. In an embodiment, the index of triggered event type is l, where $1 \le l \le L$ and L is the total number of triggered event types. Inter-arrival time of triggered events may be modeled by a Poisson distribution with a mean inter-arrival time λ_l. Triggered events may have various event record sizes, denoted by random variable S_l. Variable S_l may be modeled by a discrete Gaussian distribution $N_l(m_l, \sigma_l^2)$. The parameter m is the mean or expectation (location of the peak) and σ2 is the variance. σ is known as the standard deviation. The distribution with m=0 and σ2=1 is called the standard normal distribution or the unit normal distribution.

Periodic event measurements may be taken at regular or irregular intervals. In an embodiment, n is denoted as the index of periodic measurement event type, where $1 \le n \le N$, and N is the total number of periodic measurement event types. Inter-arrival time of periodic measurement events is constant λ_n. Periodic measurement events of one type may have event record sizes of one discrete distribution with discrete probability density function Ψ_n, e.g., a discrete exponential distribution.

Events may be collected by a NE and packaged into network packets. These network packets may be sent by each NE to a centralized OAM data sink. This may be modeled by a multiple access channel. In an embodiment, x is denoted as the index of NE, where $1 \le x \le X$ and X is the total number of NEs served by the OAM data sink. The index of the packet is j, $P_{j,x}$ is the packet size of NE's packet number j, and $T_{j,x}$ is the time that NE x's packet number j is sent. Each NE may work independently and may not be aware of another NE's condition and transmission behavior. If bursts from different NEs happen at the same time, the receiving end (OAM data sink) may experience a heavy traffic load condition which may cause data loss. In order to mitigate processing load on the OAM data sink, in an embodiment, each NE may normalize the size of event data packets (i.e., uniform packet size) sent to OAM data sink to reduce the packet size Peak-to-Average Ratio (PAR) of each

NE's packet stream so that the OAM data sink has less chance to have a large overall PAR. For example, each NE connected to a common OAM data sink may be configured to send a packet stream when a normalized size of an event data packet is reached instead of sending OAM data that have varying packet size immediately when compiled. The target (average) packet size is denoted by P. The packet size of the event data packet may be based on the type of event data packet, such as triggered or periodic, time period waiting for a packet to become normalized, emergency situation, or other situations like the situations disclosed herein.

In an embodiment, each NE may normalize the packet inter-arrival time to OAM data sink to reduce packet inter-arrival time PAR of each NE's packet stream. For example, each NE connected to a common OAM data sink may be configured to send a packet stream every 2 seconds instead of sending OAM data immediately when compiled. The target (average) packet inter-arrival time is denoted by T.

The variable δ_i is the difference between the time that measurement event i is recorded to measurement event record i, to the time measurement event record i is available in the OAM data sink. The i th measurement event record is the instance when an event was measured. By reducing the variation of the series of δ_i, the OAM data sink may have a more stable incoming data rate and, in turn, a more stable processor utilization. Without such handling, the large amount of incoming data and bursty data may cause data loss. The target (average) latency is denoted by Δ.

The variable ξ_i may be defined as the difference between the time that call-level event i is recorded to call-level event record i, to the time call-level event record i is available in the OAM data sink. An objective may be to have all call-level event records that are associated with a single call, come to the OAM data sink at the same time, i.e., ξ_i==t for all i that are associated to a single call.

In order to balance performance and utilize the techniques discussed herein, a priority-weighting approach may be applied as shown in Table 1. An EMS may instruct a network element or controller to send data more or less frequently based on the weight. The objective function may be maximized using recursive algorithms or block-wise algorithms.

TABLE 1

Packet size weight $W_{j,x}{}^{P} = \lvert P_{j,x} - P\rvert^{-1}$
Packet inter-arrival time weight $W_{j,x}{}^{T} = \lvert T_{j,x} - T\rvert^{-1}$
Measurement event latency weight $W_i{}^{\Delta} = \lvert\delta_i - \Delta\rvert^{-1}$
Call-level event latency weight
$W_i{}^{\Xi} = \lvert\xi_i - \xi_n\rvert^{-1}$ where n is the index of the event which is the first event of the same call
Objective function
$w = \sum_{j,l} (W_{j,x}^{P} + W_{j,x}^{T} + W_i^{\Delta} + W_i^{\Xi})$

Embodiments disclosed herein may allow collected OAM data to be evaluated and used for near real time network adjustments. Prior art systems may be aggregated and send data directly to the EMS with no coordination, which is not scalable. Here, the embodiments disclosed may allow for real-time OAM and control, including real-time RF profiling and optimization; real-time customer experience management, social event handling; network outage and disaster management and recovery. Embodiments herein may create networks for handling the increased network throughput of LTE including increasing the probability OAM data may not exceed the capacity limit. Also, the embodiments disclosed may allow data transport in a very efficient manner and mitigate bursty scenarios. For example, an EMS may instruct polling at smaller intervals when problems arise or during a predefined day and time.

A probing system may become network-aware and accommodate various types of network conditions, and effectively perform in LTE, UMTS, and the like networks. A probing system may probe (query) network devices for network errors, network congestion or usage, and other diagnostic data. In an embodiment, the probing system may dynamically detect or anticipate a congested network condition and turn off probing during or prior to traffic congestion. For example, a probing system may anticipate traffic congestion based on analysis of previous traffic congestion. Here, the probing system may be configured to turn off probing which may normally occur every 10 minutes, until traffic congestion has stopped. The probing system may restart probing at a predetermined time or may restart probing after receiving a message from a network device associated with the traffic congestion.

In an embodiment, a probing system may probe more frequently during emergency situations. Emergency situations may be defined by an end user, network operator, or the like. An example of an emergency situation may be a time period during or a time period closely after or before a natural disaster related event. Another example of emergency situation may be when a network node is showing signs of failure. For example, constant errors, moments of unreachability, and other patterns that may signal a complete failure or other problems.

FIG. **3** illustrates a non-limiting exemplary method of implementing one or more disclosed embodiments of intelligent network diagnosis and evaluation. In an embodiment, a probing system may probe less frequently during normal (sunny day) situations. In method **300** at block **310**, a node may be configured to probe every 5 minutes during the beginning of the day (for example). At block **320** the probing system may probe a network element. At block **330**, the probing system may receive and analyze the requested diagnostic data from the network element. At block **340**, the probing system may determine whether the diagnostic data positively or negatively meets particular thresholds. If the probing system meets the defined thresholds, at block **350**, the probing system is configured to probe less frequently and adds 1 minute to its probing time (i.e., every 6 minutes). If the probing system does not meet the defined threshold, at block **360**, the probing system is configured to probe more frequently and decreases the probing time (i.e., every 4 minutes). The probing system may be configured to linearly or by some other function, for example, increase or decrease the time between probes after positive analysis of data. In another embodiment, an increase of 30 seconds of probing time (i.e., less frequent) for positive results (e.g., no errors or congestion then 5 minutes and 30 seconds). There also may be a decrease of 10 seconds in probing time (i.e., more frequent) where there are negative results (e.g., a non-responsive NE or errors).

In an embodiment, the packets sent by a probing system may be set to a high level of quality of service. This may be particularly useful when there is an emergency. For example, when there is an emergency situation the probing system packets may change from best effort to a high quality of service. In an embodiment, a probing system may setup a threshold or latency trigger. For example, when an alarm, such as a threshold for latency is passed, there may be a change in the frequency as well as the type of conditions probed for.

The probing systems described herein are unlike prior art probing systems (e.g., 3GPP 25.914). Prior art probing systems used in LTE and UMTS networks exclusively probe using best efforts and collect service level agreement (SLA) measurements for monthly usage. The probing systems described herein, although discussed in separate exemplary embodiments, may be modified to combine or delete features of the exemplary embodiments.

FIG. **4** illustrates an example wireless device **1010** that may be used in connection with an embodiment. References will also be made to other figures of the present disclosure as appropriate. For example, mobile devices **110** and **111** may be wireless devices of the type described in regard to FIG. **4**, and may have some, all, or none of the components and modules described in regard to FIG. **4**. It will be appreciated that the components and modules of wireless device **1010** illustrated in FIG. **4** are illustrative, and that any number and type of components and/or modules may be present in wireless device **1010**. In addition, the functions performed by any or all of the components and modules illustrated in FIG. **4** may be performed by any number of physical components. Thus, it is possible that in some embodiments the functionality of more than one component and/or module illustrated in FIG. **4** may be performed by any number or types of hardware or a combination of hardware and software.

Processor **1021** may be any type of circuitry that performs operations on behalf of wireless device **1010**. Such circuitry may include circuitry and other components that enable processor **1021** to perform any of the functions and methods described herein. Such circuitry and other components may also enable processor **1021** to communicate and/or interact with other devices and components, for example any other component of device of wireless device **1010**, in such a manner as to enable processor **118** and such other devices and/or components to perform any of the disclosed functions and methods. In one embodiment, processor **1021** executes software (computer readable instructions stored in a computer readable storage medium which is not a transient signal) that may include functionality related to intelligent network diagnosis and evaluation, for example. User interface module **1022** may be any type or combination of hardware or a combination of hardware and software that enables a user to operate and interact with wireless device **1010**, and, in one embodiment, to interact with a system or software enabling the user to place, request, and/or receive calls, text communications of any type, voicemail, voicemail notifications, voicemail content and/or data, and/or a system or software enabling the user to view, modify, or delete related software objects. For example, user interface module **1022** may include a display, physical and/or “soft” keys, voice recognition software, a microphone, a speaker and the like. Wireless communication module **1023** may be any type of transceiver including any combination of hardware or a combination of hardware and software that enables wireless device **1010** to communicate with wireless network equipment. Memory **1024** enables wireless device **1010** to store information, such as APNs, MNCs, MCCs, text communications content and associated data, multimedia content, software to efficiently process radio resource requests and service requests, and radio resource request processing preferences and configurations. Memory **1024** may take any form, such as internal random access memory (RAM), an SD card, a microSD card and the like. Power supply **1025** may be a battery or other type of power input (e.g., a charging cable that is connected to an electrical outlet, etc.) that is capable of powering wireless device **1010**. SIM **1026** may be any type Subscriber Identity Module and may be configured on a removable or non-removable SIM card that allows wireless device **1010** to store data on SIM **1026**.

FIG. **5** is a block diagram of an example processor **1158** which may be employed in any of the embodiments described herein, including as one or more components of mobile devices **110** and **111**, as one or more components of network equipment such as MMEs, and HSSs, and/or CMS, or any other component of networks **110** and **111**, and/or any related equipment, and/or as one or more components of any third party system or subsystem that may implement any portion of the subject matter described herein. It is emphasized that the block diagram depicted in FIG. **5** is exemplary and not intended to imply a specific implementation. Thus, the processor **1158** can be implemented in a single processor or multiple processors. Multiple processors can be distributed or centrally located. Multiple processors can communicate wirelessly, via hard wire, or a combination thereof. Processor **1158** may include circuitry and other components that enable processor **1158** to perform any of the functions and methods described herein. Such circuitry and other components may also enable processor **1158** to communicate and/or interact with other devices and components, for example any other component of any device disclosed herein or any other device, in such a manner as to enable processor **1158** and such other devices and/or components to perform any of the disclosed functions and methods.

As depicted in FIG. **5**, the processor **1158** comprises a processing portion **1160**, a memory portion **1162**, and an input/output portion **1164**. The processing portion **1160**, memory portion **1162**, and input/output portion **1164** are coupled together (coupling not shown in FIG. **5**) to allow communications between these portions. The input/output portion **1164** is capable of providing and/or receiving components, commands, and/or instructions, utilized to, for example, request and receive APNs, MNCs, and/or MCCs, establish and terminate communications sessions, transmit and receive service requests and data access request data and responses, transmit, receive, store and process text, data, and voice communications, execute software that efficiently processes radio resource requests, receive and store service requests and radio resource requests, radio resource request processing preferences and configurations, and/or perform any other function described herein.

The processor **1158** may be implemented as a client processor and/or a server processor. In a basic configuration, the processor **1158** may include at least one processing portion **1160** and memory portion **1162**. The memory portion **1162** can store any information utilized in conjunction with establishing, transmitting, receiving, and/or processing text, data, and/or voice communications, communications-related data and/or content, voice calls, other telephonic communications, etc. For example, the memory portion is capable of storing APNs, MNCs, MCCs, service requests, radio resource requests, QoS and/or APN parameters, software for intelligent network diagnosis and evaluation, text and data communications, calls, voicemail, multimedia content, visual voicemail applications, etc. Depending upon the exact configuration and type of processor, the memory portion **1162** can be volatile (such as RAM) **1166**, non-volatile (such as ROM, flash memory, etc.) **1168**, or a combination thereof. The processor **1158** can have additional features/functionality. For example, the processor **1158** may include additional storage (removable storage **1170** and/or non-removable storage **1172**) including, but not limited to, magnetic or optical disks, tape, flash, smart cards or a combination thereof. Computer storage media, such as memory and storage elements **1162**, **1170**, **1172**, **1166**, and **1168**, may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information such as computer readable instructions, data structures, program modules, or other data. Computer storage media include, but are not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, universal serial bus (USB) compatible memory, smart cards, or any other medium that can be used to store the desired information and that can be accessed by the processor **1158**. Any such computer storage media may be part of the processor **1158** and is not a transient signal.

The processor **1158** may also contain the communications connection(s) **1180** that allow the processor **1158** to communicate with other devices, for example through a radio access network (RAN). Communications connection(s) **1180** is an example of communication media. Communication media typically embody computer-readable instructions, data structures, program modules or other data in a modulated data signal such as a carrier wave or other transport mechanism and includes any information delivery media. The term "modulated data signal" means a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media includes wired media such as a wired network or direct-wired connection as might be used with a land line telephone, and wireless media such as acoustic, RF, infrared, cellular, and other wireless media. The term computer-readable media as used herein includes both storage media and communication media, wherein storage media is not a transient signal. The processor **1158** also can have input device(s) **1176** such as keyboard, keypad, mouse, pen, voice input device, touch input device, etc. Output device(s) **1174** such as a display, speakers, printer, etc. also can be included.

A RAN as described herein may comprise any telephony radio network, or any other type of communications network, wireline or wireless, or any combination thereof. The following description sets forth some exemplary telephony radio networks, such as the global system for mobile communications (GSM), and non-limiting operating environments. The below-described operating environments should be considered non-exhaustive, however, and thus the below-described network architectures merely show how intelligent network diagnosis and evaluation may be implemented with stationary and non-stationary network structures and architectures in order to do intelligent network diagnosis and evaluation. It can be appreciated, however, that intelligent network diagnosis and evaluation as described herein may be incorporated with existing and/or future alternative architectures for communication networks as well.

The GSM is one of the most widely utilized wireless access systems in today's fast growing communication environment. The GSM provides circuit-switched data services to subscribers, such as mobile telephone or computer users. The General Packet Radio Service (GPRS), which is an extension to GSM technology, introduces packet switching to GSM networks. The GPRS uses a packet-based wireless communication technology to transfer high and low speed data and signaling in an efficient manner. The GPRS attempts to optimize the use of network and radio resources, thus enabling the cost effective and efficient use of GSM network resources for packet mode applications.

The exemplary GSM/GPRS environment and services described herein also may be extended to 3G services, such as Universal Mobile Telephone System (UMTS), Frequency Division Duplexing (FDD) and Time Division Duplexing (TDD), High Speed Packet Data Access (HSPDA), cdma2000 1× Evolution Data Optimized (EVDO), Code Division Multiple Access-2000 (cdma2000 3×), Time Division Synchronous Code Division Multiple Access (TD-SCDMA), Wideband Code Division Multiple Access (WCDMA), Enhanced Data GSM Environment (EDGE), International Mobile Telecommunications-2000 (IMT-2000), Digital Enhanced Cordless Telecommunications (DECT), 4G Services such as Long Term Evolution (LTE), etc., as well as to other network services that become available in time. In this regard, intelligent network diagnosis and evaluation may be applied independently of the method of data transport and does not depend on any particular network architecture or underlying protocols.

FIG. **6** depicts an overall block diagram of an exemplary packet-based mobile cellular network environment, such as a GPRS network, in which intelligent network diagnosis and evaluation such as those described herein may be practiced. In an example configuration, any RAN as described herein may be encompassed by or interact with the network environment depicted in FIG. **6**. Similarly, mobile devices **110** and **111** may communicate or interact with a network environment such as that depicted in FIG. **6**. In such an environment, there may be a plurality of Base Station Subsystems (BSS) **900** (only one is shown), each of which comprises a Base Station Controller (BSC) **902** serving a plurality of Base Transceiver Stations (BTS) such as BTSs **904**, **906**, and **908**. BTSs **904**, **906**, **908**, etc. are the access points where users of packet-based mobile devices (e.g., mobile devices **110** and **111**) become connected to the wireless network. In exemplary fashion, the packet traffic originating from user devices (e.g., mobile devices **110** and **111**) may be transported via an over-the-air interface to a BTS **908**, and from the BTS **908** to the BSC **902**. Base station subsystems, such as BSS **900**, may be a part of internal frame relay network **910** that can include Service GPRS Support Nodes (SGSN) such as SGSN **912** and **914**. Each SGSN may be connected to an internal packet network **920** through which a SGSN **912**, **914**, etc. may route data packets to and from a plurality of gateway GPRS support nodes (GGSN) **922**, **924**, **926**, etc. As illustrated, SGSN **914** and GGSNs **922**, **924**, and **926** may be part of internal packet network **920**. Gateway GPRS serving nodes **922**, **924** and **926** may provide an interface to external Internet Protocol (IP) networks, such as Public Land Mobile Network (PLMN) **950**, corporate intranets **940**, or Fixed-End System (FES) or the public Internet **930**. As illustrated, subscriber corporate network **940** may be connected to GGSN **924** via firewall **932**, and PLMN **950** may be connected to GGSN **924** via border gateway router **934**. The Remote Authentication Dial-In User Service (RADIUS) server **942** may be used for caller authentication when a user of a mobile cellular device calls corporate network **940**.

Generally, there can be four different cell sizes in a GSM network, referred to as macro, micro, pico, and umbrella cells. The coverage area of each cell is different in different environments. Macro cells may be regarded as cells in which the base station antenna is installed in a mast or a building above average roof top level. Micro cells are cells whose antenna height is under average roof top level. Micro-cells may be typically used in urban areas. Pico cells are small cells having a diameter of a few dozen meters. Pico cells may be used mainly indoors. On the other hand, umbrella cells may be used to cover shadowed regions of smaller cells and fill in gaps in coverage between those cells.

FIG. **7** illustrates an architecture of a typical GPRS network in which one or more disclosed embodiments of intelligent network diagnosis and evaluation may be implemented. The architecture if FIG. **7** is segmented into four groups: users **1050**, radio access network **1060**, core network **1070**, and interconnect network **1080**. Users **1050** may comprise a plurality of end users (though only mobile subscriber **1055** is shown in FIG. **7**). In an example embodiment, the device depicted as mobile subscriber **1055** may comprise any of mobile devices **110** and **111**. Radio access network **1060** comprises a plurality of base station subsystems such as BSSs **1062**, which include BTSs **1064** and BSCs **1066**. Core network **1070** comprises a host of various network elements. As illustrated here, core network **1070** may comprise Mobile Switching Center (MSC) **1071**, Service Control Point (SCP) **1072**, gateway MSC **1073**, SGSN **1076**, Home Location Register (HLR) **1074**, Authentication Center (AuC) **1075**, Domain Name Server (DNS) **1077**, and GGSN **1078**. Interconnect network **1080** may also comprise a host of various networks and other network elements. As illustrated in FIG. **7**, interconnect network **1080** comprises Public Switched Telephone Network (PSTN) **1082**, Fixed-End System (FES) or Internet **1084**, firewall **1088**, and Corporate Network **1089**.

A mobile switching center may be connected to a large number of base station controllers. At MSC **1071**, for instance, depending on the type of traffic, the traffic may be separated in that voice may be sent to Public Switched Telephone Network (PSTN) **1082** through Gateway MSC (GMSC) **1073**, and/or data may be sent to SGSN **1076** that may send the data traffic to GGSN **1078** for further forwarding.

When MSC **1071** receives call traffic, for example, from BSC **1066**, it may send a query to a database hosted by SCP **1072**. The SCP **1072** may process the request and may issue a response to MSC **1071** so that it may continue call processing as appropriate.

The HLR **1074** may be a centralized database for users to register to the GPRS network. In some embodiments, HLR **1074** may be a device such as HSSs. HLR **1074** may store static information about the subscribers such as the International Mobile Subscriber Identity (IMSI), APN profiles as described herein, subscribed services, and a key for authenticating the subscriber. HLR **1074** may also store dynamic subscriber information such as dynamic APN profiles and the current location of the mobile subscriber. HLR **1074** may also serve to intercept and determine the validity of destination numbers in messages sent from a device, such as mobile subscriber **1055**, as described herein. Associated with HLR **1074** may be AuC **1075**. AuC **1075** may be a database that contains the algorithms for authenticating subscribers and may include the associated keys for encryption to safeguard the user input for authentication.

In the following, depending on context, the term "mobile subscriber" sometimes refers to the end user and sometimes to the actual portable device, such as mobile devices **110** and **111**, used by an end user of a mobile cellular service or a wireless provider. When a mobile subscriber turns on his or her mobile device, the mobile device may go through an attach process by which the mobile device attaches to an SGSN of the GPRS network. In FIG. **7**, when mobile subscriber **1055** initiates the attach process by turning on the network capabilities of the mobile device, an attach request may be sent by mobile subscriber **1055** to SGSN **1076**. The SGSN **1076** queries another SGSN, to which mobile subscriber **1055** was attached before, for the identity of mobile subscriber **1055**. Upon receiving the identity of mobile subscriber **1055** from the other SGSN, SGSN **1076** may request more information from mobile subscriber **1055**. This information may be used to authenticate mobile subscriber **1055** to SGSN **1076** by HLR **1074**. Once verified, SGSN **1076** sends a location update to HLR **1074** indicating the change of location to a new SGSN, in this case SGSN **1076**. HLR **1074** may notify the old SGSN, to which mobile subscriber **1055** was attached before, to cancel the location process for mobile subscriber **1055**. HLR **1074** may then notify SGSN **1076** that the location update has been performed. At this time, SGSN **1076** sends an Attach Accept message to mobile subscriber **1055**, which in turn sends an Attach Complete message to SGSN **1076**.

After attaching itself to the network, mobile subscriber **1055** may then go through the authentication process. In the authentication process, SGSN **1076** may send the authentication information to HLR **1074**, which may send information back to SGSN **1076** based on the user profile that was part of the user's initial setup. The SGSN **1076** may then send a request for authentication and ciphering to mobile subscriber **1055**. The mobile subscriber **1055** may use an algorithm to send the user identification (ID) and password to SGSN **1076**. The SGSN **1076** may use the same algorithm and compares the result. If a match occurs, SGSN **1076** authenticates mobile subscriber **1055**.

Next, the mobile subscriber **1055** may establish a user session with the destination network, corporate network **1089**, by going through a Packet Data Protocol (PDP) activation process. Briefly, in the process, mobile subscriber **1055** may request access to an Access Point Name (APN), for example, UPS.com, and SGSN **1076** may receive the activation request from mobile subscriber **1055**. SGSN **1076** may then initiate a Domain Name Service (DNS) query to learn which GGSN node has access to the UPS.com APN. The DNS query may be sent to the DNS server within the core network **1070**, such as DNS **1077**, that may be provisioned to map to one or more GGSN nodes in the core network **1070**. Based on the APN, the mapped GGSN **1078** may access the requested corporate network **1089**. The SGSN **1076** may then send to GGSN **1078** a Create Packet Data Protocol (PDP) Context Request message that contains necessary information. The GGSN **1078** may send a Create PDP Context Response message to SGSN **1076**, which may then send an Activate PDP Context Accept message to mobile subscriber **1055**.

Once activated, data packets of the call made by mobile subscriber **1055** may then go through radio access network **1060**, core network **1070**, and interconnect network **1080**, in a particular fixed-end system, or Internet **1084** and firewall **1088**, to reach corporate network **1089**.

Thus, network elements that can invoke the functionality of intelligent network diagnosis and evaluation such as those described herein may include, but are not limited to, Gateway GPRS Support Node tables, Fixed End System router tables, firewall systems, VPN tunnels, and any number of other network elements as required by the particular digital network.

FIG. **8** illustrates another exemplary block diagram view of a GSM/GPRS/IP multimedia network architecture **1100** in which the systems and methods for intelligent network diagnosis and evaluation such as those described herein may be incorporated. As illustrated, architecture **1100** of FIG. **8** includes a GSM core network **1101**, a GPRS network **1130** and an IP multimedia network **1138**. The GSM core network **1101** includes a Mobile Station (MS) **1102**, at least one Base

Transceiver Station (BTS) **1104** and a Base Station Controller (BSC) **1106**. The MS **1102** is physical equipment or Mobile Equipment (ME), such as a mobile telephone or a laptop computer (e.g., mobile devices **110** and **111**) that is used by mobile subscribers, in one embodiment with a Subscriber identity Module (SIM). The SIM includes an International Mobile Subscriber Identity (IMSI), which is a unique identifier of a subscriber. The SIM may also include APNs. The BTS **1104** may be physical equipment, such as a radio tower, that enables a radio interface to communicate with the MS. Each BTS may serve more than one MS. The BSC **1106** may manage radio resources, including the BTS. The BSC may be connected to several BTSs. The BSC and BTS components, in combination, are generally referred to as a base station (BSS) or radio access network (RAN) **1103**.

The GSM core network **1101** may also include a Mobile Switching Center (MSC) **1108**, a Gateway Mobile Switching Center (GMSC) **1110**, a Home Location Register (HLR) **1112**, Visitor Location Register (VLR) **1114**, an Authentication Center (AuC) **1118**, and an Equipment Identity Register (EIR) **1116**. The MSC **1108** may perform a switching function for the network. The MSC may also perform other functions, such as registration, authentication, location updating, handovers, and call routing. The GMSC **1110** may provide a gateway between the GSM network and other networks, such as an Integrated Services Digital Network (ISDN) or Public Switched Telephone Networks (PSTNs) **1120**. Thus, the GMSC **1110** provides interworking functionality with external networks.

The HLR **1112** may be a database that may contain administrative information regarding each subscriber registered in a corresponding GSM network. Such information may include APNs and APN profiles. The HLR **1112** may also contain the current location of each MS. The VLR **1114** may be a database that contains selected administrative information from the HLR **1112**. The VLR may contain information necessary for call control and provision of subscribed services for each MS currently located in a geographical area controlled by the VLR. The HLR **1112** and the VLR **1114**, together with the MSC **1108**, may provide the call routing and roaming capabilities of GSM. The AuC **1116** may provide the parameters needed for authentication and encryption functions. Such parameters allow verification of a subscriber's identity. The EIR **1118** may store security-sensitive information about the mobile equipment.

A Short Message Service Center (SMSC) **1109** allows one-to-one short message service (SMS), or multimedia message service (MMS), messages to be sent to/from the MS **1102**. A Push Proxy Gateway (PPG) **1111** is used to "push" (i.e., send without a synchronous request) content to the MS **1102**. The PPG **1111** acts as a proxy between wired and wireless networks to facilitate pushing of data to the MS **1102**. A Short Message Peer to Peer (SMPP) protocol router **1113** may be provided to convert SMS-based SMPP messages to cell broadcast messages. SMPP is a protocol for exchanging SMS messages between SMS peer entities such as short message service centers. The SMPP protocol is often used to allow third parties, e.g., content suppliers such as news organizations, to submit bulk messages.

To gain access to GSM services, such as voice, data, short message service (SMS), and multimedia message service (MMS), the MS may first register with the network to indicate its current location by performing a location update and IMSI attach procedure. MS **1102** may send a location update including its current location information to the MSC/VLR, via BTS **1104** and BSC **1106**. The location information may then be sent to the MS's HLR. The HLR may be updated with the location information received from the MSC/VLR. The location update may also be performed when the MS moves to a new location area. Typically, the location update may be periodically performed to update the database as location updating events occur.

GPRS network **1130** may be logically implemented on the GSM core network architecture by introducing two packet-switching network nodes, a serving GPRS support node (SGSN) **1132**, a cell broadcast and a Gateway GPRS support node (GGSN) **1134**. The SGSN **1132** may be at the same hierarchical level as the MSC **1108** in the GSM network. The SGSN may control the connection between the GPRS network and the MS **1102**. The SGSN may also keep track of individual MS's locations and security functions and access controls.

Cell Broadcast Center (CBC) **1133** may communicate cell broadcast messages that are typically delivered to multiple users in a specified area. Cell Broadcast is one-to-many geographically focused service. It enables messages to be communicated to multiple mobile telephone customers who are located within a given part of its network coverage area at the time the message is broadcast.

GGSN **1134** may provide a gateway between the GPRS network and a public packet network (PDN) or other IP networks **1136**. That is, the GGSN may provide interworking functionality with external networks, and set up a logical link to the MS through the SGSN. When packet-switched data leaves the GPRS network, it may be transferred to an external TCP-IP network **1136**, such as an X.25 network or the Internet. In order to access GPRS services, the MS first attaches itself to the GPRS network by performing an attach procedure. The MS then activates a packet data protocol (PDP) context, thus activating a packet communication session between the MS, the SGSN, and the GGSN.

In a GSM/GPRS network, GPRS services and GSM services may be used in parallel. The MS may operate in one three classes: class A, class B, and class C. A class A MS may attach to the network for both GPRS services and GSM services simultaneously. A class A MS may also support simultaneous operation of GPRS services and GSM services. For example, class A mobiles may receive GSM voice/data/SMS calls and GPRS data calls at the same time.

A class B MS may attach to the network for both GPRS services and GSM services simultaneously. However, a class B MS does not support simultaneous operation of the GPRS services and GSM services. That is, a class B MS can only use one of the two services at a given time.

A class C MS can attach for only one of the GPRS services and GSM services at a time. Simultaneous attachment and operation of GPRS services and GSM services is not possible with a class C MS.

GPRS network **1130** may be designed to operate in three network operation modes (NOM1, NOM2 and NOM3). A network operation mode of a GPRS network may be indicated by a parameter in system information messages transmitted within a cell. The system information messages may direct an MS where to listen for paging messages and how to signal towards the network. The network operation mode represents the capabilities of the GPRS network. In a NOM1 network, a MS may receive pages from a circuit switched domain (voice call) when engaged in a data call. The MS may suspend the data call or take both simultaneously, depending on the ability of the MS. In a NOM2 network, a MS may not receive pages from a circuit switched domain when engaged in a data call, since the MS may be receiving data and may not be listening to a paging channel. In a

NOM3 network, a MS may monitor pages for a circuit switched network while receiving data and vice versa.

The IP multimedia network **1138** was introduced with 3GPP Release 5, and may include IP multimedia subsystem (IMS) **1140** to provide rich multimedia services to end users. A representative set of the network entities within IMS **1140** are a call/session control function (CSCF), a media gateway control function (MGCF) **1146**, a media gateway (MGW) **1148**, and a master subscriber database, called a home subscriber server (HSS) **1150**. HSS **1150** may be common to GSM core network **1101**, GPRS network **1130** as well as IP multimedia network **1138**.

IP multimedia system **1140** may be built around the call/session control function, of which there are three types: an interrogating CSCF (I-CSCF) **1143**, a proxy CSCF (P-CSCF) **1142**, and a serving CSCF (S-CSCF) **1144**. The P-CSCF **1142** is the MS's first point of contact with the IMS **1140**. The P-CSCF **1142** may forward session initiation protocol (SIP) messages received from the MS to an SIP server in a home network (and vice versa) of the MS. The P-CSCF **1142** may also modify an outgoing request according to a set of rules defined by the network operator (for example, address analysis and potential modification).

I-CSCF **1143** forms an entrance to a home network and hides the inner topology of the home network from other networks and provides flexibility for selecting an S-CSCF. I-CSCF **1143** may contact subscriber location function (SLF) **1145** to determine which HSS **1150** to use for the particular subscriber, if multiple HSSs **1150** are present. S-CSCF **1144** may perform the session control services for MS **1102**. This includes routing originating sessions to external networks and routing terminating sessions to visited networks. S-CSCF **1144** may also decide whether an application server (AS) **1152** is required to receive information on an incoming SIP session request to ensure appropriate service handling. This decision may be based on information received from HSS **1150** (or other sources, such as application server **1152**). AS **1152** may also communicate to location server **1156** (e.g., a Gateway Mobile Location Center (GMLC)) that provides a position (e.g., latitude/longitude coordinates) of MS **1102**.

HSS **1150** may contain a subscriber profile and keep track of which core network node is currently handling the subscriber. It may also support subscriber authentication and authorization functions (AAA). In networks with more than one HSS **1150**, a subscriber location function provides information on the HSS **1150** that contains the profile of a given subscriber.

MGCF **1146** may provide interworking functionality between SIP session control signaling from the IMS **1140** and ISUP/BICC call control signaling from the external GSTN networks (not shown.) It may also control the media gateway (MGW) **1148** that provides user-plane interworking functionality (e.g., converting between AMR- and PCM-coded voice.) MGW **1148** may also communicate with other IP multimedia networks **1154**.

Push to Talk over Cellular (PoC) capable mobile telephones may register with the wireless network when the telephones are in a predefined area (e.g., job site, etc.) When the mobile telephones leave the area, they may register with the network in their new location as being outside the predefined area. This registration, however, does not indicate the actual physical location of the mobile telephones outside the pre-defined area.

FIG. **9** illustrates a PLMN block diagram view of an exemplary architecture in which one or more disclosed embodiments of intelligent network diagnosis and evaluation may be implemented. Mobile Station (MS) **1301** is the physical equipment used by the PLMN subscriber. In one illustrative embodiment, communications device **40** may serve as Mobile Station **1301**. Mobile Station **1301** may be one of, but not limited to, a cellular telephone, a cellular telephone in combination with another electronic device or any other wireless mobile communication device.

Mobile Station **1301** may communicate wirelessly with Base Station System (BSS) **1310**. BSS **1310** contains a Base Station Controller (BSC) **1311** and a Base Transceiver Station (BTS) **1312**. BSS **1310** may include a single BSC **1311**/BTS **1312** pair (Base Station) or a system of BSC/BTS pairs which are part of a larger network. BSS **1310** is responsible for communicating with Mobile Station **1301** and may support one or more cells. BSS **1310** is responsible for handling cellular traffic and signaling between Mobile Station **1301** and Core Network **1340**. Typically, BSS **1310** performs functions that include, but are not limited to, digital conversion of speech channels, allocation of channels to mobile devices, paging, and transmission/reception of cellular signals.

Additionally, Mobile Station **1301** may communicate wirelessly with Radio Network System (RNS) **1320**. RNS **1320** contains a Radio Network Controller (RNC) **1321** and one or more Node(s) B **1322**. RNS **1320** may support one or more cells. RNS **1320** may also include one or more RNC **1321**/Node B **1322** pairs or alternatively a single RNC **1321** may manage multiple Nodes B **1322**. RNS **1320** is responsible for communicating with Mobile Station **1301** in its geographically defined area. RNC **1321** is responsible for controlling the Node(s) B **1322** that are connected to it and is a control element in a UMTS radio access network. RNC **1321** performs functions such as, but not limited to, load control, packet scheduling, handover control, security functions, as well as controlling Mobile Station **1301**'s access to the Core Network (CN) **1340**.

The evolved UMTS Terrestrial Radio Access Network (E-UTRAN) **1330** is a radio access network that provides wireless data communications for Mobile Station **1301** and User Equipment **1302**. E-UTRAN **1330** provides higher data rates than traditional UMTS. It is part of the Long Term Evolution (LTE) upgrade for mobile networks and later releases meet the requirements of the International Mobile Telecommunications (IMT) Advanced and are commonly known as a 4G networks. E-UTRAN **1330** may include of series of logical network components such as E-UTRAN Node B (eNB) **1331** and E-UTRAN Node B (eNB) **1332**. E-UTRAN **1330** may contain one or more eNBs. User Equipment **1302** may be any user device capable of connecting to E-UTRAN **1330** including, but not limited to, a personal computer, laptop, mobile device, wireless router, or other device capable of wireless connectivity to E-UTRAN **1330**. The improved performance of the E-UTRAN **1330** relative to a typical UMTS network allows for increased bandwidth, spectral efficiency, and functionality including, but not limited to, voice, high-speed applications, large data transfer and IPTV, while still allowing for full mobility.

An exemplary embodiment of a mobile data and communication service that may be implemented in the PLMN architecture described in FIG. **9** is the Enhanced Data rates for GSM Evolution (EDGE). EDGE is an enhancement for GPRS networks that implements an improved signal modulation scheme known as 9-PSK (Phase Shift Keying). By increasing network utilization, EDGE may achieve up to three times faster data rates as compared to a typical GPRS network. EDGE may be implemented on any GSM network capable of hosting a GPRS network, making it an ideal upgrade over GPRS since it may provide increased functionality of existing network resources. Evolved EDGE networks are becoming standardized in later releases of the radio telecommunication standards, which provide for even greater efficiency and peak data rates of up to 1 Mbit/s, while still allowing implementation on existing GPRS-capable network infrastructure.

Typically Mobile Station **1301** may communicate with any or all of BSS **1310**, RNS **1320**, or E-UTRAN **1330**. In a illustrative system, each of BSS **1310**, RNS **1320**, and E-UTRAN **1330** may provide Mobile Station **1301** with access to Core Network **1340**. The Core Network **1340** may include of a series of devices that route data and communications between end users. Core Network **1340** may provide network service functions to users in the Circuit Switched (CS) domain, the Packet Switched (PS) domain or both. The CS domain refers to connections in which dedicated network resources are allocated at the time of connection establishment and then released when the connection is terminated. The PS domain refers to communications and data transfers that make use of autonomous groupings of bits called packets. Each packet may be routed, manipulated, processed or handled independently of all other packets in the PS domain and does not require dedicated network resources.

The Circuit Switched—Media Gateway Function (CS-MGW) **1341** is part of Core Network **1340**, and interacts with Visitor Location Register (VLR) and Mobile-Services Switching Center (MSC) Server **1360** and Gateway MSC Server **1361** in order to facilitate Core Network **1340** resource control in the CS domain. Functions of CS-MGW **1341** include, but are not limited to, media conversion, bearer control, payload processing and other mobile network processing such as handover or anchoring. CS-MGW **1340** may receive connections to Mobile Station **1301** through BSS **1310**, RNS **1320** or both.

Serving GPRS Support Node (SGSN) **1342** stores subscriber data regarding Mobile Station **1301** in order to facilitate network functionality. SGSN **1342** may store subscription information such as, but not limited to, the International Mobile Subscriber Identity (IMSI), temporary identities, or Packet Data Protocol (PDP) addresses. SGSN **1342** may also store location information such as, but not limited to, the Gateway GPRS Support Node (GGSN) **1344** address for each GGSN where an active PDP exists. GGSN **1344** may implement a location register function to store subscriber data it receives from SGSN **1342** such as subscription or location information.

Serving Gateway (S-GW) **1343** is an interface which provides connectivity between E-UTRAN **1330** and Core Network **1340**. Functions of S-GW **1343** include, but are not limited to, packet routing, packet forwarding, transport level packet processing, event reporting to Policy and Charging Rules Function (PCRF) **1350**, and mobility anchoring for inter-network mobility. PCRF **1350** uses information gathered from S-GW **1343**, as well as other sources, to make applicable policy and charging decisions related to data flows, network resources and other network administration functions. Packet Data Network Gateway (PDN-GW) **1345** may provide user-to-services connectivity functionality including, but not limited to, network-wide mobility anchoring, bearer session anchoring and control, and IP address allocation for PS domain connections.

Home Subscriber Server (HSS) **1363** is a database for user information, and stores subscription data regarding Mobile Station **1301** or User Equipment **1302** for handling calls or data sessions. Networks may contain one HSS **1363** or more if additional resources are required. Exemplary data stored by HSS **1363** include, but is not limited to, user identification, numbering and addressing information, security information, or location information. HSS **1363** may also provide call or session establishment procedures in both the PS and CS domains.

The VLR/MSC Server **1360** provides user location functionality. When Mobile Station **1301** enters a new network location, it begins a registration procedure. A MSC Server for that location transfers the location information to the VLR for the area. A VLR and MSC Server may be located in the same computing environment, as is shown by VLR/MSC Server **1360**, or alternatively may be located in separate computing environments. A VLR may contain, but is not limited to, user information such as the IMSI, the Temporary Mobile Station Identity (TMSI), the Local Mobile Station Identity (LMSI), the last known location of the mobile station, or the SGSN where the mobile station was previously registered. The MSC server may contain information such as, but not limited to, procedures for Mobile Station **1301** registration or procedures for handover of Mobile Station **1301** to a different section of the Core Network **1340**. GMSC Server **1361** may serve as a connection to alternate GMSC Servers for other mobile stations in larger networks.

Equipment Identity Register (EIR) **1362** is a logical element which may store the International Mobile Equipment Identities (IMEI) for Mobile Station **1301**. In a typical embodiment, user equipment may be classified as either “white listed” or “black listed” depending on its status in the network. In one embodiment, if Mobile Station **1301** is stolen and put to use by an unauthorized user, it may be registered as “black listed” in EIR **1362**, preventing its use on the network. Mobility Management Entity (MME) **1364** is a control node which may track Mobile Station **1301** or User Equipment **1302** if the devices are idle. Additional functionality may include the ability of MME **1364** to contact an idle Mobile Station **1301** or User Equipment **1302** if retransmission of a previous session is required.

While example embodiments of systems and methods for intelligent network diagnosis and evaluation have been described in connection with various communications devices and computing devices/processors, the underlying concepts can be applied to any communications or computing device, processor, or system capable of implementing the intelligent network diagnosis and evaluation described. The various techniques described herein may be implemented in connection with hardware or a combination of hardware and software. Thus, the methods and apparatuses for intelligent network diagnosis and evaluation, or certain aspects or portions thereof, can take the form of program code (i.e., instructions) embodied in tangible and/or a medium that is not a transient signal, such as floppy diskettes, CD-ROMs, hard drives, or any other machine-readable storage medium, wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for intelligent network diagnosis and evaluation. In the case of program code execution on programmable computers, the computing device will generally include a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. The program(s) can be implemented in assembly or machine language, if desired. The language can be a compiled or interpreted language, and combined with hardware implementations.

Methods and systems for intelligent network diagnosis and evaluation may also be practiced via communications embodied in the form of program code that is transmitted over some transmission medium, such as over electrical wiring or cabling, through fiber optics, or via any other form of transmission, wherein, when the program code is received, loaded into, and executed by a machine, such as an EPROM, a gate array, a programmable logic device (PLD), a client computer, or the like, the machine becomes an apparatus for intelligent network diagnosis and evaluation. When implemented on a general-purpose processor, the program code combines with the processor to provide a unique apparatus that operates to invoke the functionality of intelligent network diagnosis and evaluation as described herein. Additionally, any storage techniques used in connection with an intelligent network diagnosis and evaluation system may invariably be a combination of hardware and software.

While intelligent network diagnosis and evaluation have been described in connection with the various embodiments of the various figures, it is to be understood that other similar embodiments may be used or modifications and additions may be made to the described embodiments for performing the same function of intelligent network diagnosis and evaluation without deviating therefrom. For example, one skilled in the art will recognize intelligent network diagnosis and evaluation as described in the present application may apply to any environment, whether wired or wireless, and may be applied to any number of such devices connected via a communications network and interacting across the network. Therefore, intelligent network diagnosis and evaluation should not be limited to any single embodiment, but rather should be construed in breadth and scope in accordance with the appended claims.

What is claimed is:

1. A method comprising:

processing, by a network element, an event data packet into a first operations, administration, and maintenance (OAM) data packet, the first OAM data packet being one of a plurality of OAM data packets;

determining a normalized packet size of each data packet of the plurality of OAM data packets based on a status of the network element, the status of the network element comprising a status of traffic congestion of a network associated with the network element;

receiving instructions from an OAM server to transmit each data packet of the plurality of OAM data packets at a frequency based on a priority weighting, the priority weighting based on a packet size; and

transmitting, by the network element to the OAM server, the first OAM data packet based on the instructions.

2. The method of claim **1**, wherein processing of the event data packet comprises compressing data of the event data packet.

3. The method of claim **1**, wherein the first OAM data packet further comprises a plurality of processed event data packets.

4. The method of claim **1**, wherein the normalized packet size is additionally based on a type of event, the type of event comprising whether the event is a periodic event.

5. The method of claim **4**, wherein the network element status further comprises at least one of an emergency status of a network, a normal operating status of the network, or network error status of the network.

6. The method of claim **1**, further comprising regulating rate of transmission based on regional network conditions.

7. The method of claim **1**, wherein the priority weighting is also based on an inter-arrival time associated with an event.

8. A network device comprising:

a processor; and

a memory coupled with the processor, the memory comprising executable instructions that when executed by the processor cause the processor to effectuate operations comprising:

processing an event data packet into a first operations, administration, and maintenance (OAM) data packet, the first OAM data packet being one of a plurality of OAM data packets;

determining a normalized packet size of each data packet of the plurality of OAM data packets based on a status of a network element, the status of the network element comprising a status of traffic congestion of a network associated with the network element;

receiving instructions from an OAM server to transmit each data packet of the plurality of OAM data packets at a frequency based on a priority weighting, the priority weighting based on packet size; and

transmitting, to the OAM server, the first OAM data packet at a normalized packet based on the instruction.

9. The network device of claim **8**, wherein the network device is an OAM device.

10. The network device of claim **8**, wherein processing of the event data packet comprises compressing data of the event data packet.

11. The network device of claim **8**, wherein the first OAM data packet further comprises a plurality of processed event data packets.

12. The network device of claim **8**, wherein the normalized packet size is additionally based on a target peak-to-average ratio.

13. The network device of claim **12**, wherein the network element status further comprises at least one of an emergency status of a network, a normal operating status of the network, or network error status of the network.

14. The network device of claim **8**, wherein first data packet is set to a high quality of service level when there is an emergency.

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